An FSPM approach for modeling fruit yield and quality in mango trees

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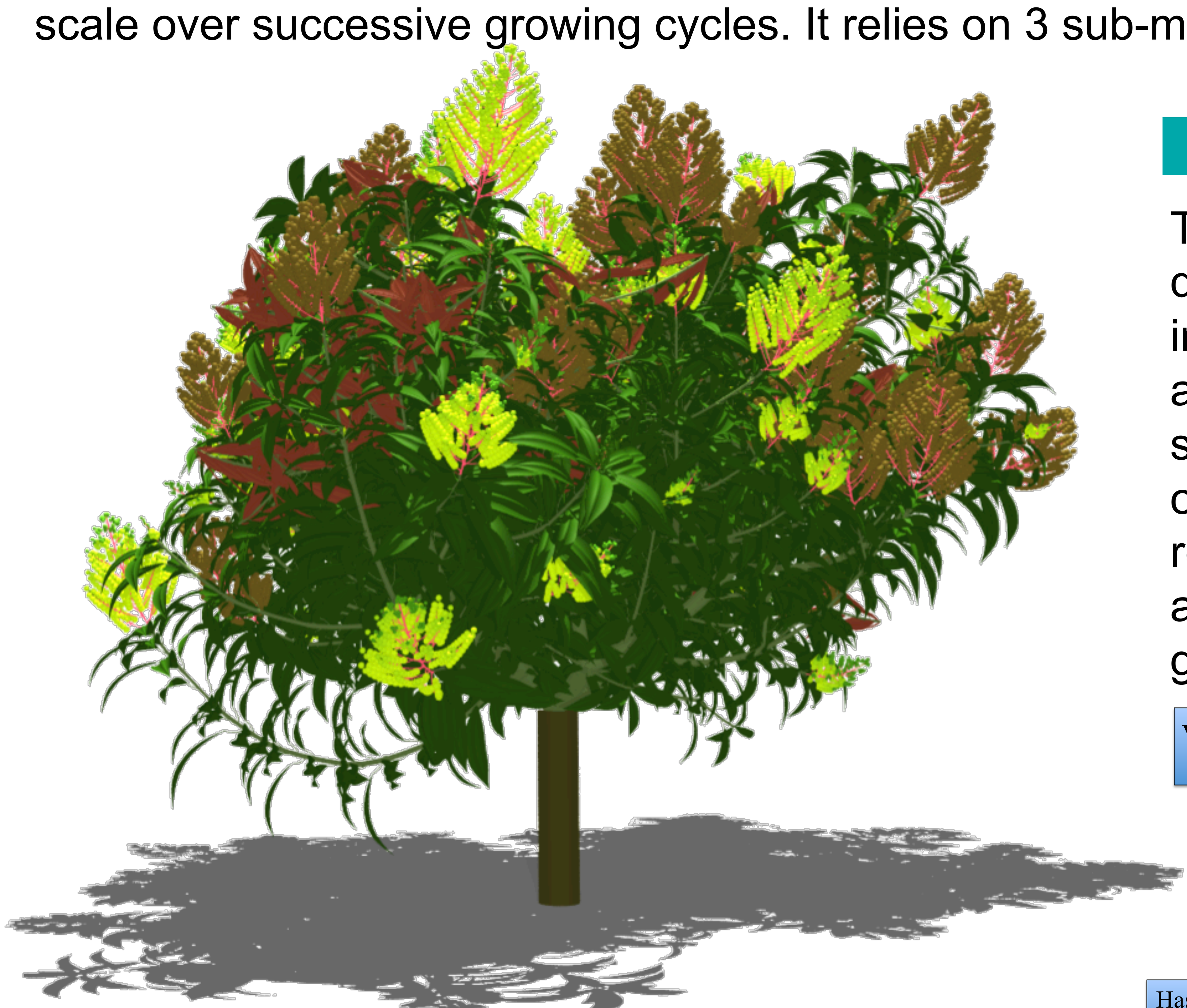
We developed an integrative model synthesizing the knowledge acquired on the vegetative and reproductive development of mango tree architecture and fruit quality built-up. Its objective was to simulate yield and fruit quality of mango trees at the tree scale over successive growing cycles. It relies on 3 sub-models.



1. Tree architecture

The appearance of the growth units (GU) and inflorescences was decomposed into elementary events describing the occurrence, the intensity and the timing of vegetative and reproductive development at the growth unit scale (Fig. 1). These events are affected by structural and temporal architectural factors (position and burst date of the mother growth unit and position and nature (quiescent or reproductive) of the terminal growth unit during the previous cycle) and the corresponding probabilities were estimated using generalized linear models.

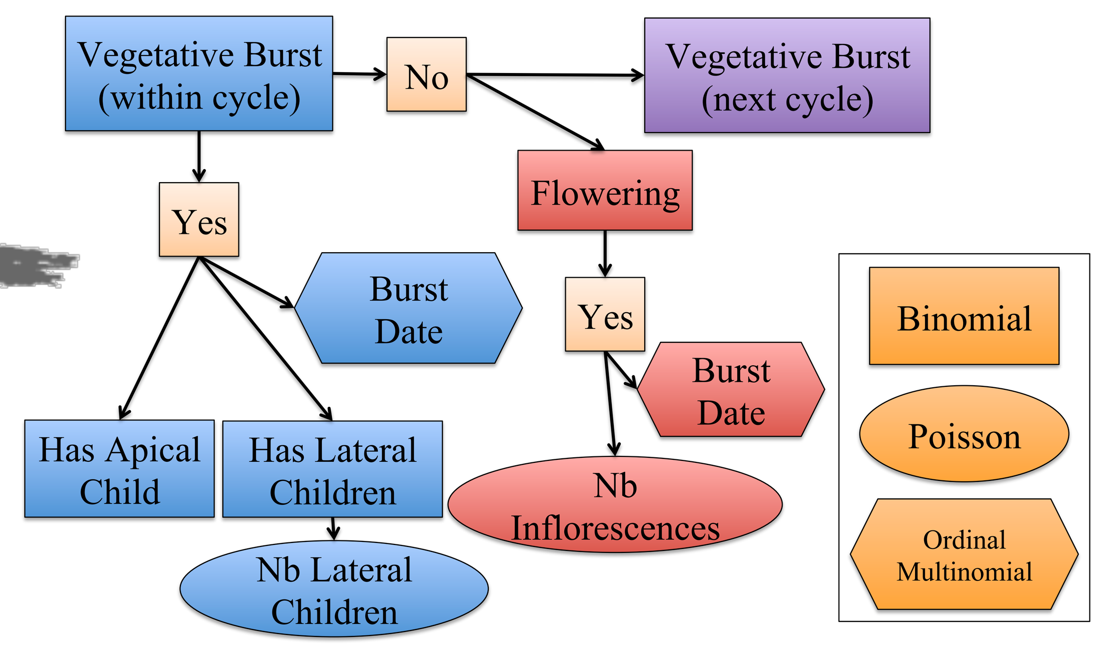


Fig. 1: The different developmental processes simulated using GLM.

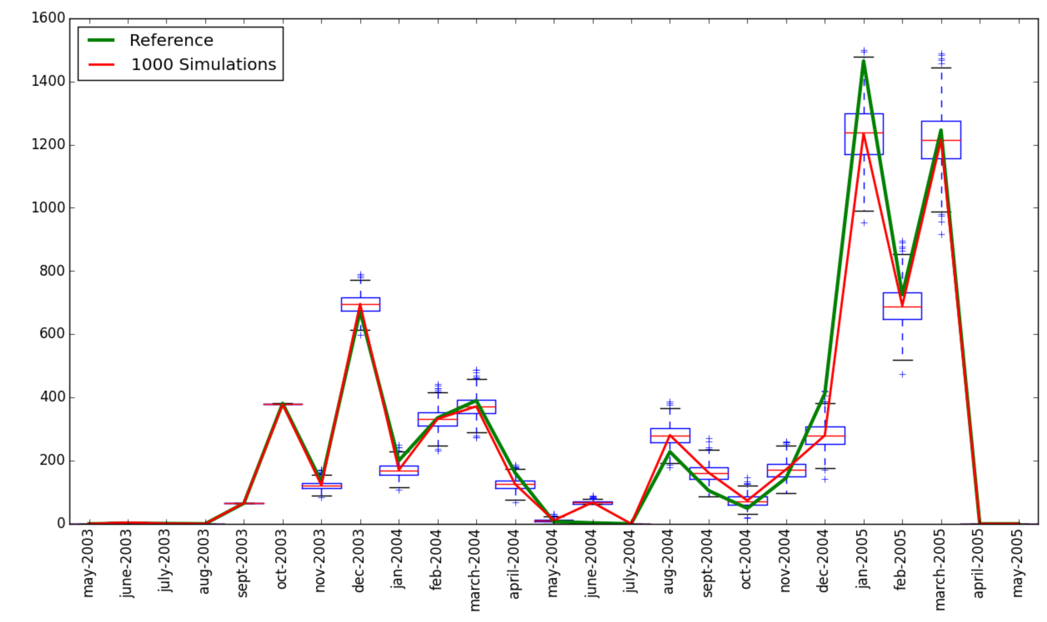


Fig. 2: The demography of the simulated growth unit population.

2. GU and inflorescences

Daily growth and development of growth units (GU) and inflorescences were modelled using empirical size distributions and thermal time. Structural factors such as the position of the growth unit and its mother affect the morphology of the growth units.

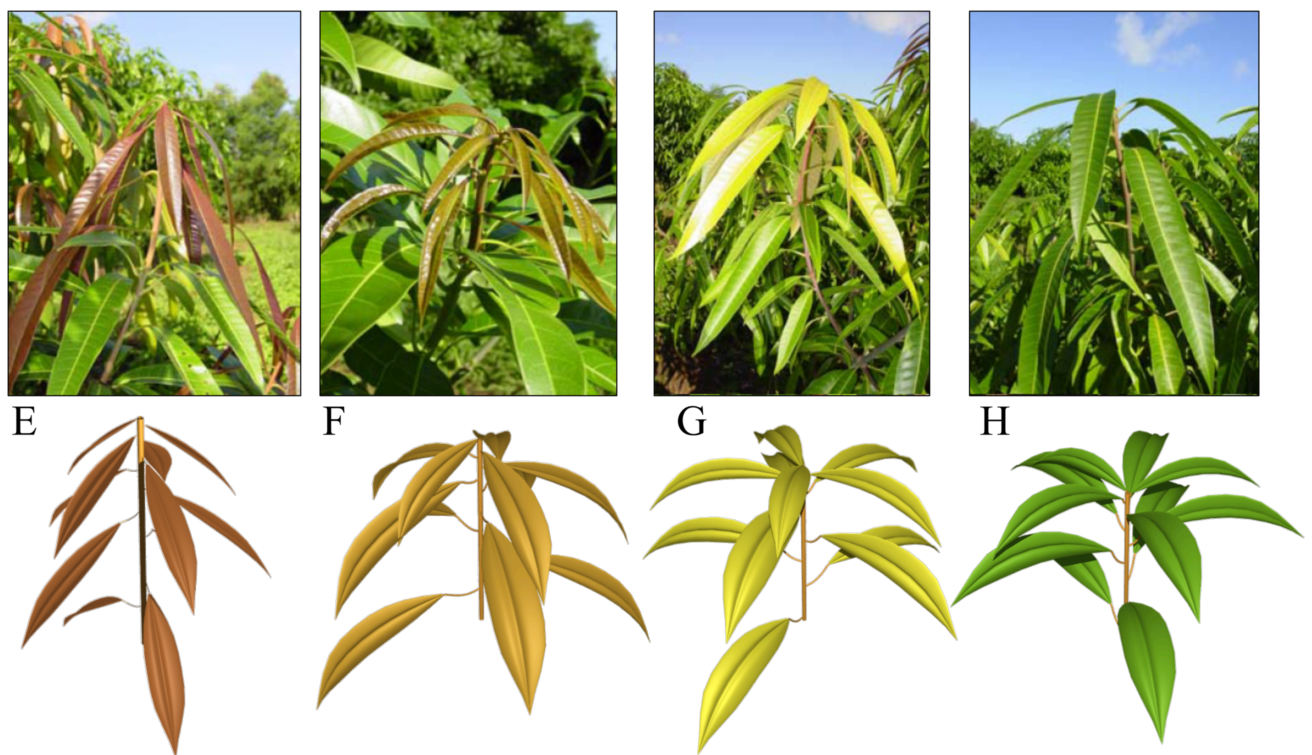


Fig. 3: Simulation of the different developmental stages of a GU with changes in leaf morphological traits (colour, orientation, size)

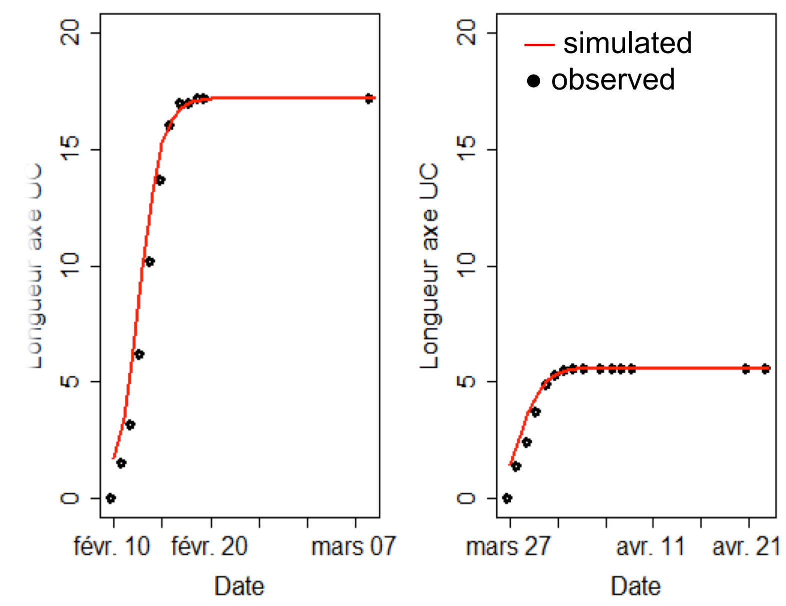


Fig. 4: Example of simulated extensions of GU axis length

3. Fruits

Fruit growth and quality are simulated by the process-based ecophysiological model [1,2]. It takes into account the effects of the environment and considers carbon- (i.e., leaf photosynthesis, mobilization/storage of reserves, respiration, demand for growth and carbon allocation) and water-related (i.e., water flows driven by stem and fruit water potentials and fruit transpiration) processes occurring at the branch level during fruit growth.

Tree	Cycle	Simulated yield (kg)	Measured yield (kg)
B10	3	10.7 ± 0.4	12.1
B10	4	39.6 ± 0.8	34.5
B12	3	5.5 ± 0.3	5.3
B12	4	47.3 ± 1.2	42
F2	3	5.4 ± 0.6	6
F2	4	50.2 ± 1.1	41

Fig. 5: Simulated versus measured fruit yield on fixed architecture with stochastic GU growth and development.

Conclusion

Simulation gives an integrative view of the dynamics of the population of growth units, inflorescences and fruits at the tree scale during a growing cycle. The model enables to investigate the variability of fruit quality within the tree, considering the different architectural context of each fruits. The next step is to include the effects of cultural practices, in particular pruning, on the mango tree development and reproduction.

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[1] Léchaudel et al., 2005. Modeling effects of weather and source-sink relationships on mango fruit growth. Tree Physiology 25,583-597.
[2] Léchaudel et al., 2007. An analysis of elastic and plastic fruit growth of mango in response to various assimilate supplies. Tree Physiology 27(2), 219-230.